

Role of Disorder in Determining the Vortex Phase Diagram in High Temperature Superconductors I

Lisa Paulius, Western Michigan University, DMR-0072880

Understanding the vortex phase diagram in high temperature superconductors is of primary importance for advancing their technological applications. Their electrical properties are determined by the static and dynamic behavior of the vortices. The amount of electrical current these materials can carry without losing any energy can be increased by adding defects which act to pin the vortices down so they can't move.

When the vortices are in the solid state, they are much easier to pin down, since the solid acts much like a rigid body. However, at high temperatures and fields the vortex solid undergoes a first order transition into a liquid state. Studying the effects of defects on this transition allows us to design more effective pinning sites. It is also of fundamental interest for understanding the basic phenomena of melting and phase transitions in general.

Figure 1 shows the effects of adding ~ 5 nm diameter columnar defects. The lower critical point H_{lcp} of the melting transition can be shifted to higher fields, greatly reducing the vortex liquid state in the phase diagram. The fact that H_{lcp} increases sharply when the vortices become aligned with the columnar defects indicates that the pinning strength of the defects plays a crucial role in the mechanism responsible for the termination of the first order melting transition at low fields.

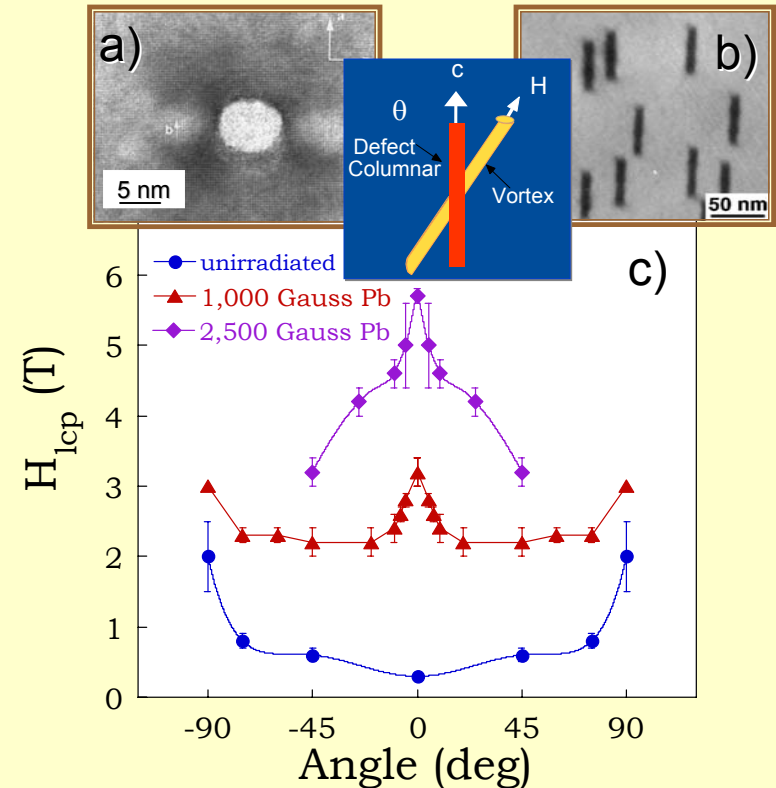


Fig. 1 TEM image of the nano-scale columnar defects introduced by heavy ion irradiation seen a) end on and b) side on. c) Effect of the defects on the angular dependence of the lower critical point in crystals with three different irradiation doses.



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Educational:

4 graduate students :

Lucian Undreiu is a 2nd year graduate student.

Talal Al-tahtamoun is a 1st year graduate student.

Andra Petrean finished her Ph.D. in Sept. 2000.

Valentina Tobos finished her Ph.D. in July 2001.

Collaborations:

George Crabtree Argonne National Laboratory

Wai Kwok, Argonne National Laboratory

Christophe Marcenat, CEA, Grenoble, France

Thierry Klein, LE PES, CNRS Grenoble, France

Outreach activities:

- Ran a tour of our laboratory with a presentation on our research attended by approximately 70 introductory physics students.
- Took part in Western Michigan University's 'Research Fair'. The week-long event focuses on enhancing the awareness of our undergraduates and prospective students of the current research being conducted on campus. It also highlights opportunities for them to participate in the research.

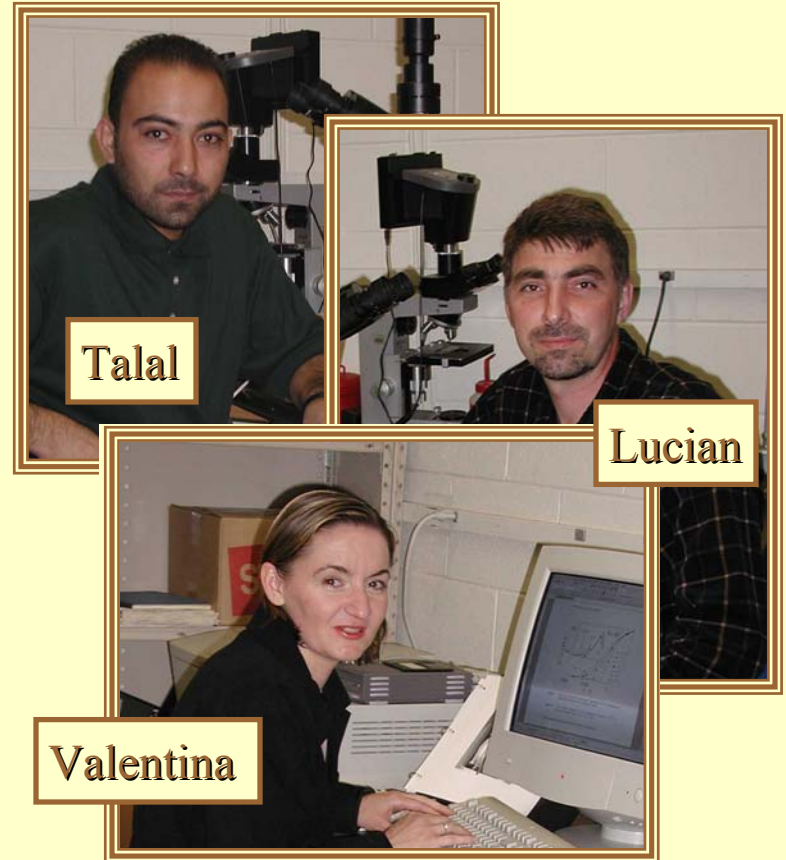


Fig. 2 Three of the four graduate students supported by this project to date.